(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 558 147 A1**

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 93200525.9

(51) Int. Cl.5: **A62B 18/00**, A62B 18/08

(22) Date of filing: **24.02.93**

(30) Priority: **26.02.92 US 841706**

(43) Date of publication of application:
01.09.93 Bulletin 93/35

(84) Designated Contracting States:
AT BE CH DE DK ES FR GB GR IE IT LI LU MC NL PT SE

(71) Applicant: **D.J.S. & T. LIMITED PARTNERSHIP**
1610 - 6th Street
Bellingham, WA 98225(US)

(72) Inventor: **Stern, Donald J.**
2078 Dellesta Drive
Bellingham, WA 98226(US)
Inventor: **Tryon, James A.**
420 Smith Street
Seattle, WA 98109(US)

(74) Representative: **Hoijtink, Reinoud**
OCTROOIBUREAU ARNOLD & SIEDSMA
Sweelinckplein 1
NL-2517 GK Den Haag (NL)

(54) Face mask assembly and method.

(57) A face mask assembly having a housing (12) and a replaceable filter (16) mounted in said housing. A fan (18) means draws air into a plenum chamber (72) defined by said housing (12) and said filter (16) for this air to pass into a facial breathing area (23). An outlet check valve (98) is provided, and a primary filter (14) through which air passes before entering said plenum chamber (72).

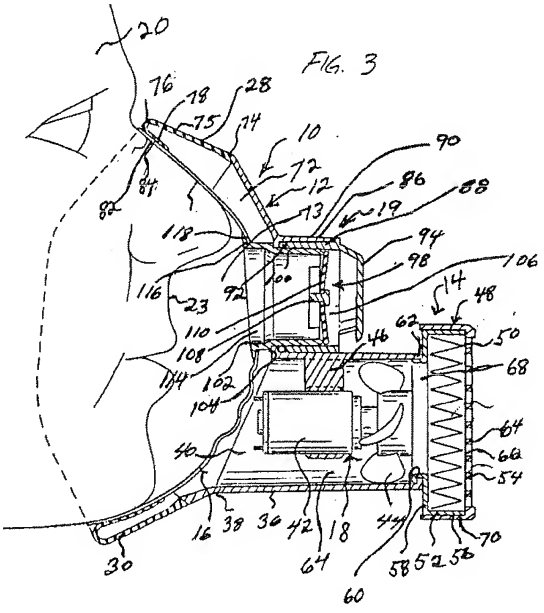


FIG. 3

EP 0 558 147 A1

Background of the Invention

A. Field of the Invention

The present invention relates to a face mask assembly for a person, and more particularly to a face mask having a replaceable filter adjacent to a person's facial breathing area and also other features directed toward sanitary use of the face mask and comfortable and effective use of a face mask, and also to a method of using the same

Background Art

The are many working environments in which it is necessary (or at least desirable) for a person to wear a face mask or other apparatus to filter the air which the person is breathing. In addition to the expected problems of arranging the filtering mechanism or other air purifying device so that it operates effectively, there are considerations relative to sanitation, ergometrics, convenience of use, and the person's comfort in allowing the breathing process to be as natural as possible. These problems or considerations are exacerbated to some extent when the mask is being worn in a situation where the person wearing the mask is doing active work that requires the person to breath air at a greater volumetric rate. For example, under these circumstances, in addition to being able to filter the air at a greater rate of volumetric flow, there may be greater condensation of moisture from the air which the person is exhaling. Also, many prior art face masks create a feeling of "stuffiness" or other type of discomfort, or some actual impediment to, or alteration of, the normal breathing process. Yet, in designing face masks to alleviate these problems, it is also desirable to make the face mask light weight, compact, economical in operation as well as manufacture, convenient to use, and also compatible with a variety of physical movements a person might be expected to perform in various tasks.

Another important consideration relates to sanitation, in that the same face mask may be worn by different persons at different times. Not just the breathing of the person, but possibly even the coughing or sneezing of the person wearing the mask could be a source of contamination that might be passed on to a person wearing the mask at a subsequent time. While ideally the face mask should be sanitized or sterilized in some manner before being worn by another, or possibly a procedure could be implemented where each person would have his or her own personalized mask which would not be used by another, such procedures may not be practical or properly adhered to. One general approach that is used in a variety of situations as a sanitation technique (e.g. a number of items used in hospital operations) is to simply make the item inexpensively and dispose of the item after its initial use. However, many items having more than a minimum of sophistication do not lend themselves to this approach.

A searching of prior art patents and literature has developed a number of items, these being listed below.

British patent specification 1,049,604 (Klavdienko) shows a "dustproof respirator" which comprises an airtight mask 1 made of an elastic material (e.g. rubber) that is held on a person's face by means of a tape 10. The mask 1 appears to comprise planar wall having a folded elastic cuff 4 that is made integral with the mask 1 and extends around the perimeter thereof. An inlet valve 2 is formed apparently at the middle of the wall of the mask 1, and an outlet valve 3 is formed at a bottom part of the mask 1. It appears that the mask 1 defines substantially the entire enclosure which isolates a portion of the person's face from the ambient atmosphere. Extending forwardly from the mask 1 is what is called a "distance plate 8" having a rear portion adjacent to the inlet valve 2 and a forward portion. It is stated that the distance plate 8 is "a perforated easily bent distance plate 8", and it would appear to be formed as a cylinder, whose axes extends forwardly from the inlet valve 2. There is an outer coarse filter 5 within which is positioned an inner fine filter 6, these being closely adjacent to one another and having the shape of a cup. The perimeter portion of these filters 5 and 6 are connected to the cuff 4 of the mask, and the central portion of these filters 5 and 6 are positioned at the forward part of the distance plate 8. Thus, it appears that the mask 1 with the valves 2 and 3 define substantially all of the surface area and in turn defines the chamber or space that is directly adjacent to the person's face and breathing area, while the two filter elements 5 and 6 are positioned outside of the chamber defined by the mask 1. It is stated that the inner fine filter 6 is changeable. In operation, outside air passes first through the coarse filter 5, and then through the inner filter 6 and thence into the inlet valve 2 so as to pass into the chamber defined by the mask 1 so that this air can be breathed in by the person. (It may be that the air actually passes through the perforated distance plate 8 before passing into the inlet valve 2). Then when the person exhales, the exhaled air passes from the chamber defined by the mask 1 out the valve 3.

U.S. 4,090,510 (Segersten) discloses a "Face Mask With a Changeable Filter". The mask 1 is made of leather or he like and has a number of holes which are punched out to admit air. The filter is made of two layers, namely a layer or sheet 7

made of a suitable cellulose to intercept coarse particles and a similar piece 8 to intercept fine particles. To form the filter, the sheet 8 is placed on the sheet 7 and then the sheet or filter 7 is folded over with the seam 9 is made so that the filter has an outside part 7 and an inside part 8. This resulting filter is joined to the mask 1 by means of two metal bands 11 fitting on the side of the mask 1.

U.S. 4,866,056 (Simpson) discloses a "breathing apparatus where there is a mask 2 that is called an 'orinasal mask'. This mask 2 has an inhale valve 8 and an exhale valve positioned on the opposite side of the mask 2, but not shown. There is a pressure sensing element 9 which responds to the person exhaling, and when the person exhales, a fan which draws air into the mask is shut off.

U.S. 5,022,900 (Bar-Yona et al) shows a particular configuration of a ventilation filtration device. There is a centrifugal type rotor and the filter extends at least in an annular configuration up along side the rotor.

U.S. 5,003,974 (Mou) shows an emergency breathing mask which is transparent and is placed over the user's head. There is a flexible air pipe feeding air into the transparent container from a case 2.

U.S. 4,971,052 (Edwards) shows a motor driven fan which draws air through a filter 16. The motor is controlled by a switch means that responds to pressure variations as the user breathes.

U.S. 4,549,542 (Chien) shows a breathing mask in which a motor drives a series of fans. One set of blades directs the air into the breathing area and a second set sucks the air from the breathing space. There may be a filter section 22 that filters the air that is drawn in.

U.S. 4,502,480 (Yamaoto) shows a breathing aid for motorcycle riders in which there is a hose that carries air from a filter placed on the front of the bike. There may be a filter element in the fan as shown in Figure 2.

U.S. 4,478,216 (Dukowski) shows a breathing filter with a face mask. There is a fan which propels air through the filter.

U.S. 4,430,995 (Hilton) shows a filtering breathing mask in which there is a fan means that supplies air to a resilient air storage bag 13.

U.S. 4,331,141 (Pokhis) shows a breathing arrangement where there is a deformable container on the person's thorax so that when the person breathes in so that the volume of the thorax increases, the container is deformed and the volume of the inner chamber decreases so that ambient air which enters the inner chamber of the container is urged to flow through the filter system.

U.S. 4,320,755 (Flint et al) shows a breathing mask filter system in which a fan 10 drives the air through a filtering element 13. Patentability seems to be directed toward specific mechanical features.

U.S. 3,736,927 (Misaqi) shows a breathing aid in which a motor powered fan blows filtered and conditioned air between the user's face and the shield.

U.S. 3,525,334 (Braman et al) shows a clean-room suit in which there is an air supply means 51 that includes a fan to supply air to the user. There is a filter element that filters their air as it leaves the suit so that the dust and like are removed from the exhaled air.

U.S. 4,646,732 (Chien) shows a respiratory mask where there is a fan 4b for drawing air through what appears to be a filter in a canister 8, and delivers this air through the passageway 43 into the interior of the mask. There is an exhaust fan 6b that draws the air from the interior of the mask and discharges it outwardly through an exhaust vent 61c.

British Patent 222 366 (Davis) relates to "gas mask and particularly to masks commonly known as double mask" (first page, column 1, line 60 and following). The inner mask a covers the nose and mouth to form a gas-tight joint, and it has inlet valves k1 that lead from the space h between the inner mask a and outer mask b into he area within the inner mask. There is an outlet valve leading from inside the inner mask to outside atmosphere. The person exhales from the inner mask a through the tube m and out a check valve 1. The incoming air enters from a source of supply through the tube j and thence through the openings n into the area h. It is stated (page 2, column 1, line 62) that the inner mask is connected at c by cement. It does not appear that this inner mask a functions as a filter since air enters the inner mask area by valves k1.

British Patent 2,044,110 (Gdulla) shows a respiratory mask rather similar in overall design to the aforementioned British Patent to Davis (No. 222,366). the inhaled air passes upwardly through the tube 1 and through the valve 11 into the inner mask 10. The exhaled air goes through a check valve 14 leading downwardly from the inner mask and also extending through the outer mask.

German Patent 1,285,893 which has a removeable inner mask, but the inner mask is not in the form of a secondary filter.

British Patent 2,173,705 (Howie) discloses a mask having a filter where there is a fan that draws the air through the filter. It is arranged so that the fan 9 can be interposed between the filter and the mask inlet, or the filter may be connected directly to the mask.

British Patent 2,222,777A (Simpson) is another example of a filter for a respiratory that has a motor driven fan drawing air into the filter.

British Patent 2,215,217 (Simpson) shows a pressure filter respirator similar to the other Simpson patent (British 2,222,777A) where there is a motor driven fan. There is a curved wall 10 within the mask to direct the air into an upper portion of the face mask.

British Patent 2,109,246 (Shyn et al) is yet another example of a mask having a motor to drive a compressor to draw the air through the filter.

British Patent 2,215,216 (Simpson) shows a mask similar to that shown in the other Simpson Patent (British Patent #2,215,217A), but in the present patent there is shown an alarm system to indicate when the pressure within the mask has declined to too low of a level.

British Patent 2,209,474A shows a respirator where there is a fan that draws air through a filter unit 10 having a replaceable filter 11.

European Patent Application 0,130,707 (O'Connor) shows a breathing apparatus where there is a fan drawing air through a filter cannister 11 and directing it through a hose 4 to a mask. The mask has an inner mask with an inlet valve and an outlet valve.

European Patent Application 0,094,757 (O'Connor) shows a pressure respirator substantially the same as that shown in European Patent 0,130,707. This patent focuses more on the concept of having the inlet valve arranged so that when the person is exhaling, even though the fan continues to operate, there is substantially no air moved into the mask.

Finally, there is shown one page of an advertisement entitled "Light weight respirator mask has self-contained blower".

Summary of the Invention

The face mask assembly of the present invention is designed to be worn by a person over a facial breathing area of the person.

This face mask assembly comprises a main housing and a replaceable filter removably mounted to the housing so that with the assembly being worn by the person, the filter is positioned to define with the person's facial breathing area an air breathing region from which the person inhales air and into which the person exhales air. The filter is arranged to have outside air pass therethrough into said air breathing region to be inhaled.

The filter is arranged so that with the assembly being worn by the person, the filter substantially encloses the air breathing region and isolates the air breathing region from the assembly. Thus, if the mask assembly is to be worn by another, the filter can be replaced with another filter to remove contamination that might have collected on the first used filter.

The housing and the filter define at least partially an intermediate plenum chamber from which air flows through said filter into said air breathing region. There is fan means arranged to draw ambient air into the plenum chamber to flow through the filter.

Also, the preferred version, the assembly comprises an outer filter through which outside air is moved by the fan means to flow into the plenum chamber. In the preferred form, the fan means draws the outside air to the outer filter and then moves the outside air into the plenum chamber.

Also, in the preferred configuration, the assembly comprises outlet check valve means which communicates with the air breathing region to discharge exhaled air from the air breathing region, and to prevent outside air to pass through said valve means into said air breathing region. The valve means comprises a valve element means and a valve mounting structure. The valve mounting structure engages at least a portion of the replaceable filter so as to function to position the replaceable filter relative to the main housing to provide the plenum chamber.

Also, in the preferred configuration, the valve mounting structure defines a passageway by-passing said inner filter and leading from said air breathing region through said valve element means to an area outside the mask assembly.

Further, in the preferred configuration, the replaceable filter has a perimeter portion positioned within a perimeter portion of the main housing, with a perimeter portion of the replaceable filter being positioned against the person's facial area with the mask assembly in its use position being worn by the person. The valve mounting structure is positioned within the perimeter portion of the housing and spaced therefrom, with the valve mounting structure and the perimeter portion of the main housing providing locating support for the replaceable filter to define the plenum chamber.

A portion of the outlet check valve means which is exposed directly to the air breathing region is removable mounted in the main housing so as to be readily removable from said face mask assembly.

In one embodiment, the fan means comprises a rotor having impellor blade means which directs the air radially outwardly into guide vanes.

Other features will become apparent from the following detailed description.

Brief Description of the Drawings

Figure 1 is a side elevational view of a first embodiment of the mask assembly of the present invention being worn by a person in its use position;

Figure 2 is a front elevational view of the first embodiment of the present invention being worn as shown in Figure 1;

Figure 3 is a view similar to Figure 1, drawn to an enlarged scale, and showing the first embodiment of the mask assembly of the present invention in section taken along a vertical center plane extending in a forward to rear direction;

Figure 4 is a sectional view of the first embodiment similar to Figure 3, showing some of the components separated from one another;

Figure 5 is an isometric view of the replaceable inner filter and outlet valve of the first embodiment;

Figure 6 is a sectional view of a second embodiment of the present invention, taken along a vertical forward to rear plane, as in Figure 3 relative to the first embodiment;

Figure 7 is an isometric view similar to Figure 5, showing the replaceable inner filter of the second embodiment with its retaining collar spaced therefrom;

Figure 8 is a view similar to Figure 6, showing yet a third embodiment of the present invention; and

Figure 9 is a view similar to Figure 7, showing the replaceable inner filter and a retaining element incorporating a check valve therein.

Figure 10 is an isometric view of a second embodiment of the present invention;

Figure 11 is a cross-sectional view taken along line 11-11 of Figure 10; and

Figure 12 is a sectional view taken along 12-12 of Figure 11.

Description of the Preferred Embodiments

The face mask assembly 10 of the first embodiment of the present invention is shown in Figures 1-5 and comprises a main housing 12, an outer or primary filter 14, an inner replaceable filter 16, a fan 18 positioned in a flow path between the outer and inner filters 14 and 16, and an air outlet or exhaust assembly 19. The mask 10 is adapted to be mounted directly to the person's head 20, this conveniently being accomplished by a pair of upper and lower mounting straps 21 and 22 that attach on opposite sides of the housing 12 and reach around the back of the person's head and neck. The mask 10 covers the facial breathing area 23 of the person, and this facial breathing area 23 can be considered to be the surface area of the person around the person's nostrils and mouth.

To describe the mask more particularly, the housing 12 comprises a main central portion 24 and an outer perimeter portion 26. The main central portion 24 is made of a more rigid plastic material and has in front elevational view a generally triangular configuration having a rounded base, with the rounded apex of the triangle beginning at the person's nose (when the mask assembly 10 is being worn) and the two sides of the triangle extending downwardly and divergently to approximately the location of the person's mouth, and with the lower portion extending down around the person's chin in a curve. The peripheral wall portion 26 is made of a more yielding rubber-like material, and the inner forward edge of this peripheral portion 26 is bonded to the outer perimeter edge of the main housing portion 24 and extends outwardly and rearwardly therefrom in a configuration to conform to the person's face and lower chin around the facial breathing area 23. More particularly, an upper part 28 of the wall portion 26 matches the configuration of the person's nose so as to extend on opposite sides of a person's nose. The lower part 30 of the wall portion 26 is positioned against the lower part of the person's chin and contoured in a curve to fit closely adjacent thereto, while the side parts 32 of the wall portion 26 are positioned adjacent to the person's cheeks on opposite sides of the person's mouth.

The aforementioned outer filter 14 and fan 18 are positioned at the lower middle part 34 of the main housing portion 24. More particularly, there is formed integrally with the main housing portion 24 a forwardly and horizontally extending cylindrically shaped fan housing 36, the rear end 38 of which is positioned at an inlet opening 40 formed in the lower middle part 34 of the main housing 24.

Mounted within the fan housing 36 is the fan 18, this comprising a battery powered motor 42 and the fan elements or blades 44 that are rotated by the motor 42. The motor 42 is supported by a mounting strut 46 that can be made of a shock absorbing material and is connected to the fan housing 36.

Mounted to the forward end of the fan housing 36 is the aforementioned primary filter 14. This primary filter 14 comprises a primary filter housing 48 having the overall configuration of a shallow cylinder, and also a primary filter element itself 50 that is positioned within the housing 48. The housing 48 is made of two sections, namely a containing section 52 and a closure cap or plate 54. The section 52 has an outer perimeter wall 56 having the shape of the shallow cylinder, and the rear edge of this perimeter wall 56 is fixedly connected to (or formed integrally with) a radially inwardly extending annular flange 58 that reaches in a short

distance to terminate in a lip 60 that connects removably by means of a snap fit to the forward edge 62 of the fan housing 36. The aforementioned closure cap or plate 54 comprises a main plate member 64 having a generally circular configuration and having a plurality of through openings 66 through which ambient air flows to pass through the filter 50 and through the front opening 68 of the fan housing 36. The closure plate section 52 also comprises a mounting collar 70 formed integrally with the plate 64 and fitting around the perimeter wall 52 in a snap fit or a friction fit.

Air that is drawn by the fan 18 through the primary filter 14 passes through the rear fan housing opening 40 into an intermediate region or plenum chamber 72 defined by the aforementioned inner filter 16 and the main housing 12, and thence through the inner filter 16 into an inner space or region 73 defined mostly by the inner filter 16 and the person's facial breathing area 23. To describe this arrangement more particularly, the perimeter wall section 26 of the main housing 12 has a forward edge 74 which is connected to the outer edge of the main housing 24, from which the wall section 26 extends outwardly and rearwardly as an outer wall portion 75 to then curve inwardly in an approximately 180 curve at 76 and then extend forwardly and inwardly in the form of a flange 78. This flange 78 is spaced inwardly from the outer wall portion 75 of the perimeter wall 26 by approximately one eighth to one quarter an inch, and is approximately half an inch to an inch in width. This flange 78 extends entirely around the perimeter of the mask assembly 10 and serves as a mounting flange to locate the perimeter portion 82 of the inner filter 16 so that the inner filter 16 is properly spaced from the maim housing 12 to form the plenum 72 between the housing 12 and filter 14, and also press this perimeter portion 82 against the person's skin surface. (As will be described later herein, the exhaust valve assembly 19 serves a similar locating function relative to the middle part of the inner filter 16.) The overall shape of the inner filter 16 corresponds generally to that of the main housing 12 but is spaced therefrom an adequate distance to form the aforementioned chamber 72.

Mounted at the centerline of the main housing portion 24 is the aforementioned exhaust assembly 19 through which the air exhaled by the person is discharged. This exhaust assembly 19 comprises an outer cylindrical housing 86 formed integrally with the main housing portion 24 and extending forwardly therefrom. Positioned within the cylindrical housing 86 is a second housing section 88 having a cylindrical mounting portion 90 which fits snugly within the aforementioned housing section 86. A seal ring 92 is positioned at the rear edge of the mounting portion 90 within the housing section 86 so as to form a seal between the members 86 and 90. The housing section 88 also comprises a forward protective plate portion 94 attached to the forward edge of the cylindrical portion 90 by means of a plurality of struts 96 that permit air to pass outwardly by and around the protective plate portion 94.

There is a valve section, generally designated 98, and this section 98 comprises a stepped cylindrical portion 100, the forward portion of which fits removably within the aforementioned cylindrical portion 90. The rear portion 102 of this portion 100 is cylindrically shaped and has a slightly larger diameter than the portion 100 so as to be stepped outwardly therefrom, thus forming a positioning shoulder 104 by which the member 100 is located within the cylindrical portion 90.

Mounted to the forward end of the member 100 is a check valve 106 which of itself may be of conventional design. More particularly, this check valve 106 comprises a central mounting stud 108 to which the flexible valve element 110 is mounted. The valve element 110 seats against the forward edge of the cylindrical member 100 to stop reverse flow, and also bears against radial support arm 112 for the stud 108. When the person exhales, the person's breath passes directly into the rear opening 114 defined by the member 100, and the valve element 110 deflects forwardly away from the forward edge of the cylindrical member 100 to permit the outward flow of the person's breath through the exhaust valve 98.

As indicated previously, the insert 100 also serves another function, which is to properly locate the central portion of the inner filter 16. More particularly, the middle portion of the inner filter is formed with a through opening 116, and the filter edge defining this opening 116 fits over a radially outwardly extending lip 118 that is formed at the rear edge of the stepped portion 102.

It will be noted in Figure 1 that the upper straps 21 connect to opposite ends of a flexible mounting element 120 that fits around the upper back portion of the person's head 20. This mounting element 120 provides one or more pockets to mount one or more batteries 122 which supply power to the fan motor 42. Only a portion 124 of one wire from the battery or batteries 122 is indicated in Figure 1, and it is to be understood that the wire or wires leading from the battery or batteries 122 to the motor 42 can be arranged in a number if ways. Also, an on/off switch is indicated at 126 at the location of the batteries 122 to control the flow of current to the motor 42. This switch 126 also could be at some other location.

As can be seen in Figures 4 and 5, the valve section 98 comprises the cylindrical mounting member 100 with the check valve 106 mounted

thereto can be preattached directly to the inner filter 16 to provide a replaceable unit made up of the inner filter 16 and the valve section 98. It will be noted that with the mask 10 in its assembled position, the only components which are in contact with or directly exposed to the person's facial area 23 are the inner filter 16 and the check valve section 98. Thus, when it is desired to have, for example, different people wear the same mask 10, for sanitary considerations, it is a simple matter to simply replace the filter 16 with the removeable valve section 98 mounted thereto from the main housing 12 and replace this with another filter 16 and valve section 98. The inner filter 16 is made of, for example, cotton, wool, a synthetic material or combinations thereof. For example, it could be made of material comparable to that used in the 3M No. 8500 filter mask. Desirably, this inner filter 16 is formed simply and inexpensively so that it is practical to replace this inner filter 16 with reasonable frequency. The outer filter 14 can be made of a variety of materials, this depending to some extent on the working environment in which the mask assembly 10 is being used. For example, the types of filter material used for the filter 14 could be the materials used in various commercially available filter cartridges.

To describe the operation of the present invention, let it be assumed that the mask 10 is in its fully assembled position, with the fan 18 installed and operating, the outer filter element 50 in place, and a replaceable inner filter 16 and valve section 98 in their installed position within the mask housing 12. The person simply places the assembled mask 10 against the person's lower face area so that the mask 10 encloses the facial breathing area 23 of the person. The mounting straps 21 and 22 are positioned around the person's head and tightened to the desirable degree so that the mask is held firmly against the person's face. It will be noted that the peripheral edge portion 82 of the inner filter 16 is positioned between the flange 78 of the perimeter wall housing portion 26 and the person's face. Accordingly, the only portion of the mask 10 to be in direct contact with the person's face is the perimeter portion 82 of the inner filter 16.

The on/off switch 126 is turned on to start the fan 18 operating. The fan 18 draws air inwardly through the perforate plate portion 64 of the cap 54, through the outer filter element 50, thence through the fan 18, and through the opening 40 into the intermediate region or plenum chamber 72. The air in the plenum chamber 72 passes through the inner filter 16 to be breathed in by the person.

When the person is inhaling, the pressure differential between the chamber 72 and that at the inner space or chamber 73 causes the air in the intermediate chamber 72 to pass through the inner filter 16 into the space 73 to be breathed in by the person. At this time, the exhaust valve section 98 is closed so that all of the air drawn inside the inner filter 16 passes first through the outer filter 14 and also through the inner filter 16. The size, power and other operating characteristics of the fan 18 are selected relative to the impedance to air flow provided by the outer filter 14 and the inner filter 16, so that when the person is breathing in, air is flowing through the inner filter 16 into the inner space 73 at an adequate pressure to approximate the normal ambient conditions where a person is inhaling during a normal breathing cycle.

When the person begins to exhale the pressure in the space 73, within the inner filter 16, being exposed directly to the air that the person is exhaling, rises slightly so that the exhaust check valve element 100 opens so that there is a flow of air from the person's mouth and/or nose directly through the exhaust valve section 98.

Overall, the components affecting the flow of air are balanced in a manner so that the pressure and flow of air on both the breathing in and breathing out of the person approximate rather closely actual breathing conditions as if no mask were being used.

A significant feature of the present invention is that as the person exhales, all of the exhaled air flowing directly from the person's mouth or nose is contained substantially entirely by the inner filter and caused to flow through exhaust valve section 98. Depending upon a number of conditions, such as ambient temperature and humidity, the volume of air which the person is inhaling and exhaling, and possibly the characteristics of the person, there will often be a certain amount of moisture in the air that the person is exhaling. Any tendency for this moisture to condense on the inner filter 16 is counteracted by the inflow of fresh outside air through the inner filter 16 and into the facial breathing area, and with the exhaled air passing essentially outwardly through the exhaust valve section 98.

As indicated earlier herein, it may be that after one person uses the mask assembly 10, this same mask assembly is to be worn by a second person. If so, the second person can simply remove the previously used inner filter 16 and valve section 98 and replace both of these with a fresh inner filter 16 and valve section 98. This would substantially alleviate the potential problem of sources of contamination from the person previously wearing the mask assembly 10 from being transmitted to the subsequent user.

There are other advantages to the arrangement of the present invention. It will be noted that the stepped mounting cylinder 100 serves a number of

functions. First, it cooperates with the opening 116 of the inner filter 16 in two ways. The stepped portion 102 and lip 118 engage the filter edge around the filter opening 116 to provide a convenient means for holding the inner filter 16 in the proper position. Also, the mounting cylinder 100 provides a breath exhaust passageway in a manner that the opening 116 in the inner filter remains aligned and in proper communication with the outlet check valve 56. Further, while providing these other functions, the mounting cylinder 100 isolates the intermediate chamber 72 from the inner region adjacent the person's facial breathing area 23. This overall arrangement uniquely solves the problem of providing the replaceable inner filter 16 as the main operating interface directly contiguous to the facial breathing area 23, while still providing for the discharge opening for the exhaust air that by-passes both the inner filter 16 and the outer filter 14. Then by also making the valve section 98 as a removeable item (and replaceable item if needed), this enables the potential areas of contamination for the subsequent user to be removed, as described previously herein. Then the valve section 98 could be either replaced, or sanitized and reused.

A second embodiment of the present invention is shown in Figures 6 and 7. Components of this second embodiment which are similar to components of the first embodiment will be given like numerical designations, with an "a" suffix distinguishing those of the second embodiment.

Thus, there is a mask 10a which comprises a main housing 12a, made up of the main housing portion 24a and the perimeter wall portion 26a. Also, there is a fan 18a and a primary filter 14a. Further, the inner filter 16a has in general the same overall configuration as the inner filter 16 of the first embodiment.

This second embodiment shown in Figures 6 and 7 differs from the first embodiment of Figures 1 through 5 in that the exhaust assembly 19a is made somewhat differently. As in the first embodiment, there is a mounting cylinder 88a which carries a forward protective plate 96a. This cylinder 86a fits around a cylindrical member 100a, but the rear end portion of the member 100a is formed integrally with the main housing portion 24a. The valve element 110a is mounted directly to this member 100a. The rear cylindrical portion 102a is formed integrally with the member 100a and integrally with the housing portion 12a, and this portion 102a receives therein a mounting collar 128 which fits within the cylindrical portion 102a. Further, this mounting collar 128 has a radially outwardly extending retaining lip 130 which fits against an inner edge 132 that forms the center opening of the inner filter 16a. It can be seen in Figure 6, that with the mounting collar 128 in place, the edge 132 that forms the central opening of the inner filter 16a is held in place by the lip 130 pressing the filter opening edge portion 128 against the rear edge against the cylindrical portion 102a.

In this second embodiment, while the inner filter 16a is replaceable, the valve section 98a cannot be readily replaced as in the first embodiment. In other respects, the second embodiment of Figures 6 and 7 is substantially similar to the embodiment shown in Figures 1 through 5.

A third embodiment of the present invention is illustrated in Figures 8 and 9. Components of this third embodiment which are similar to those of the first two embodiments will be given like numerical designations, with a "b" suffix distinguishing those of the third embodiment. This third embodiment is substantially identical to the second embodiment, except that the removeable mounting collar of the second embodiment is simply combined to be integral with the mounting cylinder 100a of the first embodiment as a single unit. Thus, the entire valve section 98b can be replaced, or removed to be sanitized and then be put back in place.

Thus, in this third embodiment, there is a mounting collar 134 having at its rear edge a peripheral lip 136 which engages the edge portion 132b of the inner filter 16b. This collar 134 extends forwardly to fit within the mounting cylinder 88b, and the check valve 106b is mounted to the forward end of a cylindrical collar 134.

A fourth embodiment of the present invention is shown in Figures 10 through 12. Components of the fourth embodiment which are similar to those of the earlier embodiments will be given like numerical designations, with a "c" distinguishing those of the fourth embodiment.

In this fourth embodiment, the mask assembly 10c comprises the main housing 12c, inner replaceable filter 16c and an air outlet assembly 19c which are rather similar to the corresponding components of the earlier embodiment. However, the arrangement of the fan 18c and of the primary filter 14c is somewhat different.

With regard to the filter 14c, instead of having a single forward mounted primary filter 14, there are two side mounted filters 14c, each of which has a filter containing section 52c and a closure cap or plate 54c.

The two containing sections 52c are mounted to a "T" shaped housing section 200 having two cylindrical laterally extending arm sections 202 and a central rearwardly extending center section 204. The two containing sections 52c each have a cylindrical passageway defining sections 206 which in addition to defining a flow passageway 208 serve to mount the related containing section 52c to the housing arm portions 202. The central housing portion 204 fits in a forward cylindrical mounting

section 210 of the fan housing 212.

The motor 42c is centrally mounted in the housing section 200 so that its center axis of rotation is longitudinally aligned in a forward to rear direction, and its output shaft 214 connects to a rotor 216 of the fan 18c. To describe the fan 18c more particularly, the rotor 216 (See Figure 12) comprises a circular plate 218 to which a plurality of impellor vanes 220 are mounted symmetrically about a center axis 222. These impellor vanes 220 have inner end portions 224 which are spaced a short distance outwardly of a central hub 226, and from the end 224 the vanes 220 extend in a radially outward curve that slants in a direction that is more parallel with the circumference of the fan at outer ends 228 thereof.

The rotation of the rotor 216 causes the impellor vanes 220 to discharge air in a radially outward direction and draw air into the center area. The aforementioned center housing section 204 has a transverse wall 230 having a center opening 232 through which outside air flows into the fan 18c at a central location within the rotor 216. Then this air is moved radially outwardly in a somewhat swirling motion by the action of the rotation of the vanes 220 rotating with the rotor 216.

Around the perimeter of the fan 18c, there is a plurality of guide vanes 234, with each adjacent set of guide vanes 234 defining a related passageway or slot 236, these slots extending moderately outwardly with a tangential slant.

The basic operation of this fourth embodiment 10c is similar to the prior three embodiments, except for the overall configuration of the mask, particularly with regard to the two primary filter sections 14c, and also, the action of the fan 18c is somewhat different than in the prior embodiments.

With regard to the differences in the configuration, it will be noted that the two primary filter sections 14c are positioned so that these are located at a lower location, with the center housing section 204 extending downwardly and forwardly. Further, the two primary filter sections 14c are positioned further rearwardly so as to be more outside the normal field of vision of the person wearing the mask. By placing the filter sections 14c at side locations, there is less interference with the vision of the person when the person's line of vision is directed downwardly and forwardly as opposed to being directed off to one side.

With regard to the action of the fan 18c, the movement of the air is accomplished by the air being drawn in through the two filters 14c, through the opening 232 into the center part of the rotor 216, with the rotation of the vanes 220 then moving this air radially outwardly. The guide vanes 234 create a uniform flow of the air outwardly, and it is surmised that this arrangement reduces unnecessary turbulence in the airflow so that as the air flows into the plenum chamber 72c between the filter 16c and the housing 12c, the energy imparted to the incoming air is translated essentially to increased pressure of the air in the plenum 72c. Also, with this air being discharged from around the perimeter of the fan 18c, it tends to pressurize the entire plenum chamber 72c more effectively for more uniform flow through the filter 16c.

It is to be recognized that various modifications could be made in the present invention without departing from the basic teachings thereof.

Claims

1. A face mask assembly to be worn by a person over a facial breathing area of the person, said mask assembly comprising:
   a. a main housing;
   b. a replaceable filter removably mounted to said housing so that with the assembly being worn by a person, the filter is positioned to define with the person's facial breathing area an air breathing region from which the person inhales air and into which the person exhales air, said filter being arranged to have outside air pass therethrough into said air breathing region to be inhaled;
   c. said filter being arranged so that with the assembly being worn by a person, the filter substantially encloses the air breathing region and isolates said air breathing region from said assembly;
   d. said housing and said filter defining at least partially an intermediate plenum chamber from which air flows through said filter into said air breathing region;
   e. fan means arranged to draw ambient air into said plenum chamber to flow through said filter.

2. The assembly as recited in Claim 1, further comprising outlet check valve means communicating with said air breathing region to discharge exhaled air from said air breathing region, and to prevent outside air to pass through said valve means into said air breathing region.

3. The assembly as recited in Claim 2, wherein said valve means comprises a valve element means and a valve mounting structure, said valve mounting structure engaging at least a portion of said filter so as to function to position said filter relative to said main housing to provide said plenum chamber.

4. The valve assembly as recited in Claim 3, wherein said valve mounting structure defines a passageway by-passing said inner filter and leading from said air breathing region through said valve element means to an area outside said mask assembly.

5. The assembly as recited in Claim 4, wherein said filter has a perimeter portion positioned within a perimeter portion of said main housing, with the perimeter portion of the filter being positioned against a person's facial surface area with the mask assembly in its use position being worn by the person, said valve mounting structure being positioned within the perimeter portion of said housing and spaced therefrom, with the valve mounting structure and the perimeter portion of the main housing providing locating support for said filter to define said plenum chamber.

6. The assembly as recited in Claim 5, wherein a portion of said outlet check valve means which is exposed directly to said air breathing region is removably mounted in said main housing so as to be readily removeable from said face mask assembly.

7. The assembly as recited in claim 2, wherein said assembly further comprises an outer filter arranged to receive outside air which passes therethrough and into said plenum chamber.

8. The assembly as recited in claim 7, wherein said fan means is arranged to draw outside air through said outer filter which is then moved by said fan means into said plenum chamber.

9. The assembly as recited in claim 1, wherein said assembly further comprises an outer filter arranged to receive outside air which passes therethrough and through said filter into said plenum chamber.

10. The assembly as recited in claim 1, wherein said fan means comprises a rotor having impellor vane means which moves air in said fan radially outwardly, and guide vane means to receive air from said impellor vane means to direct said air into said plenum chamber.

11. The assembly as recited in claim 10, wherein said rotor has an axis of rotation which extends in generally forward to rear direction, with said air being discharged from said guide vanes generally laterally around the perimeter of said fan means into said plenum chamber.

12. The assembly as recited in claim 11, wherein there are two primary filters which are arranged to receive ambient air with ambient air flowing through said primary filters into said fan means.

13. The assembly as recited in claim 12, wherein said primary filters are laterally spaced from said fan means on opposite sides of main housing.

14. The assembly as recited in claim 1, wherein said assembly further comprises two outer filters arranged to receive outside air which passes through said fan means into said plenum chamber and through said replaceable filter, said two primary filters being laterally spaced on opposite sides of said main housing.

15. A face mask assembly to be worn by a person over a facial breathing area of the person, said mask assembly comprising:
    a. a main housing;
    b. a replaceable filter removably mounted to said housing so that with the assembly being worn by a person, the filter is positioned to define with the person's facial breathing area an air breathing region from which the person inhales air and into which the person exhales air, said filter being arranged to have outside air pass therethrough into said air breathing region to be inhaled;
    c. outlet check valve means communicating with said air breathing region to discharge exhaled air from said air breathing region, and to prevent outside air to pass through said check valve means into said air breathing region;
    d. said filter being arranged so that with the assembly being worn by a person, the filter substantially encloses the air breathing region and isolates said air breathing region from said assembly, except for said check valve means;
    e. said housing and said filter defining at least partially an intermediate plenum chamber from which air flows through said filter into said air breathing region;
    f. fan means arranged to draw ambient air into said plenum chamber to flow through said filter.

FIG. 1

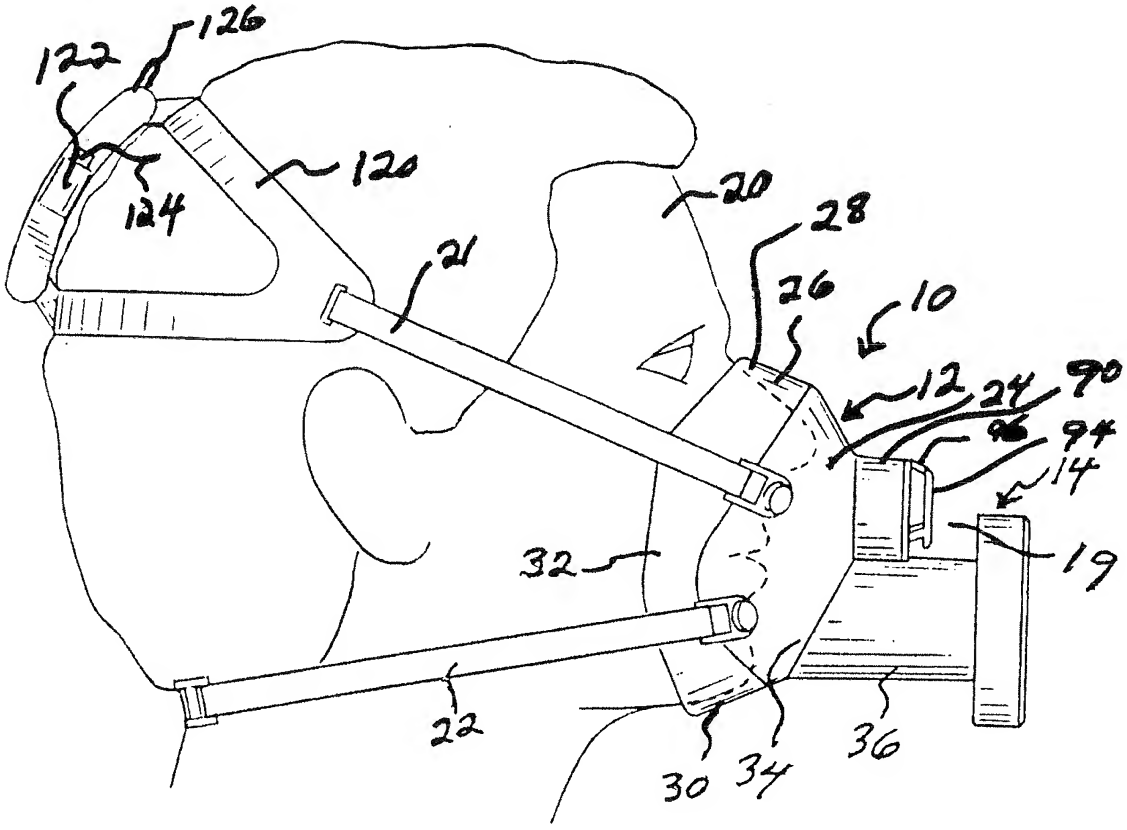
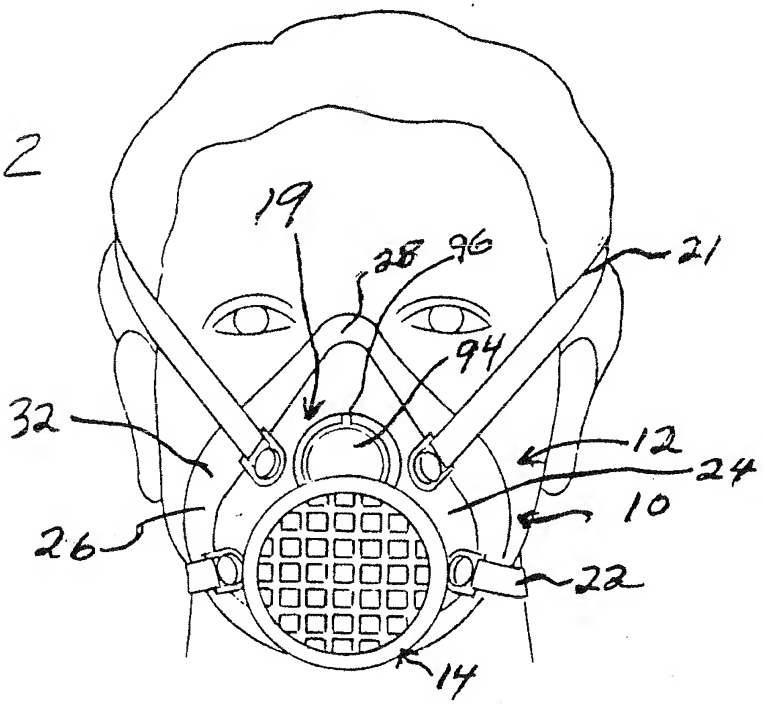

122
126
124
120
20
28
21
26
10
12
24
90
96
94
14
19
32
22
30
34
36

FIG. 2


19
28
96
21
94
32
12
24
10
26
22
14

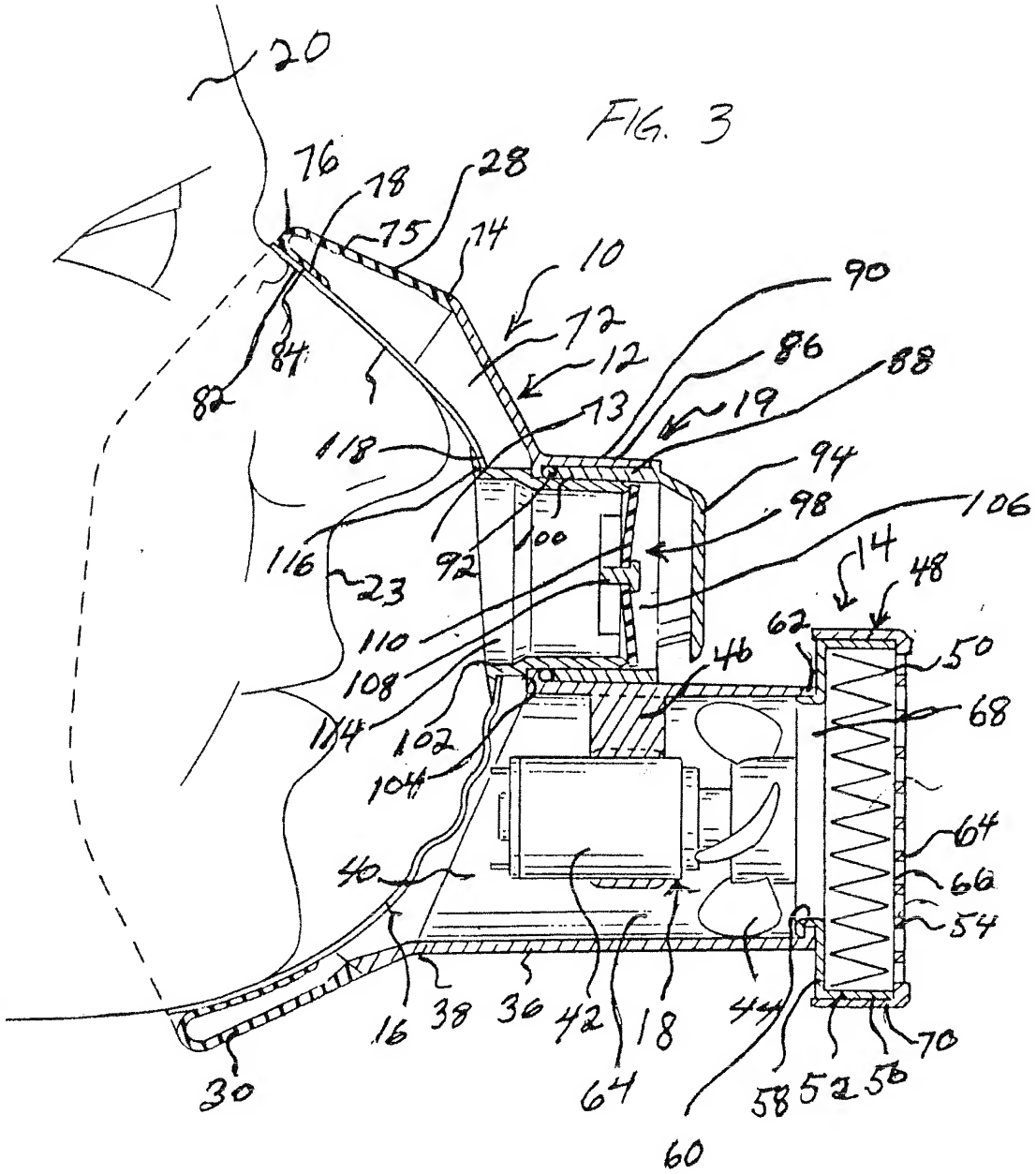

20
76
78
28
75
74
10
90
72
12
86
88
82
84
13
19
118
94
98
106
116
23
92
100
14
48
110
62
46
50
108
68
114
102
104
64
40
66
54
16
38
36
42
18
44
70
30
64
58
52
56
60

FIG. 3

FIG. 4

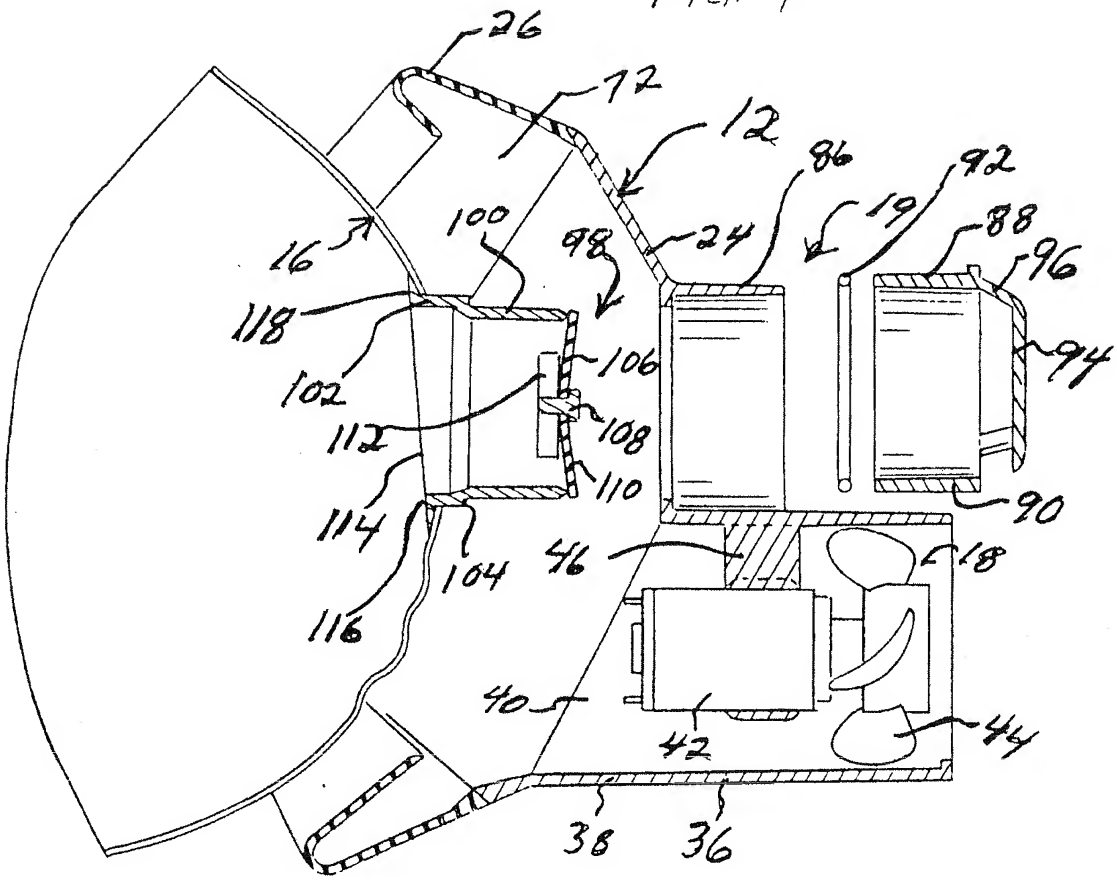

26
72
12
86
92
19
88
96
16
100
98
24
118
94
102
106
112
108
110
114
90
104
46
18
116
40
42
44
38
36

FIG. 5

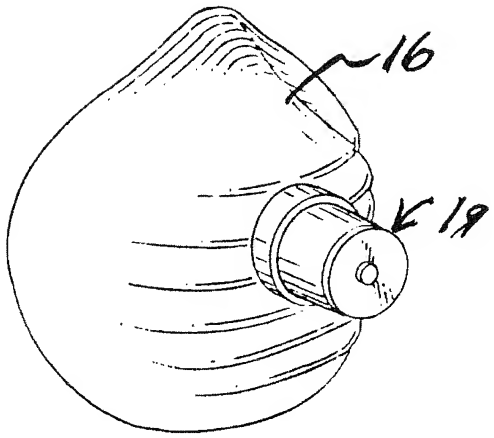


FIG. 6

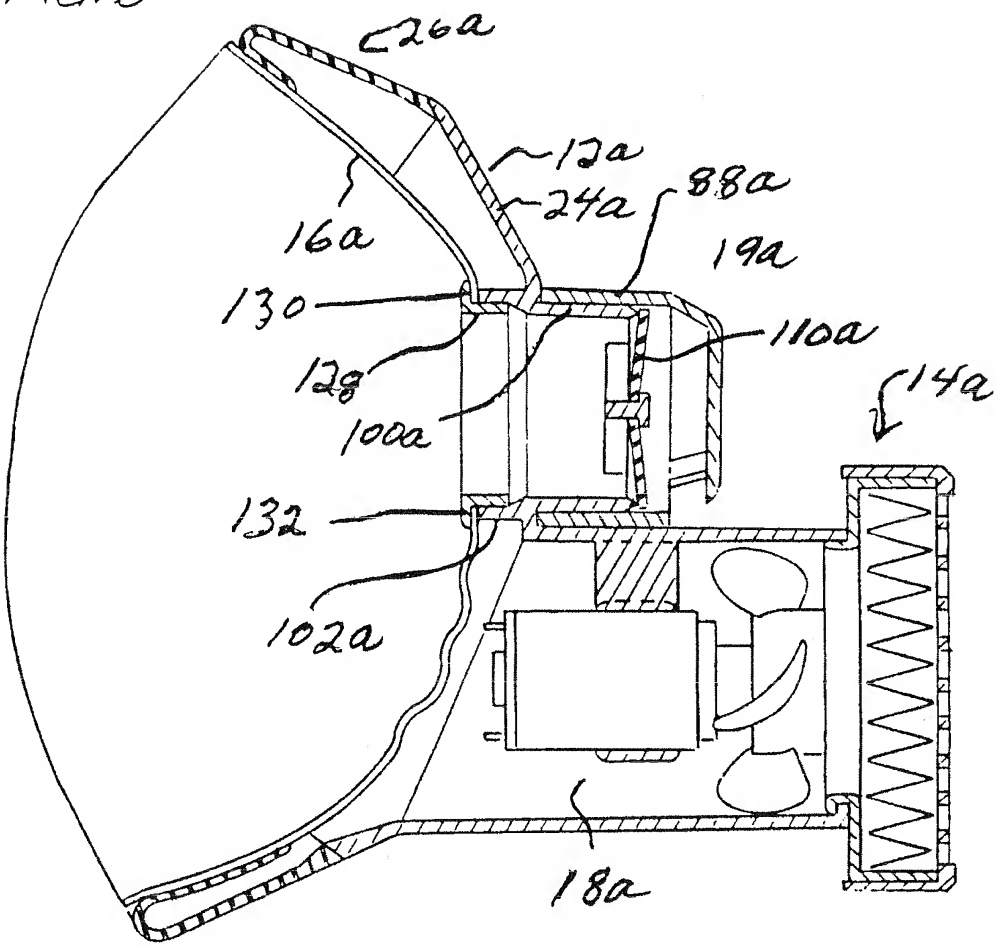


FIG. 7

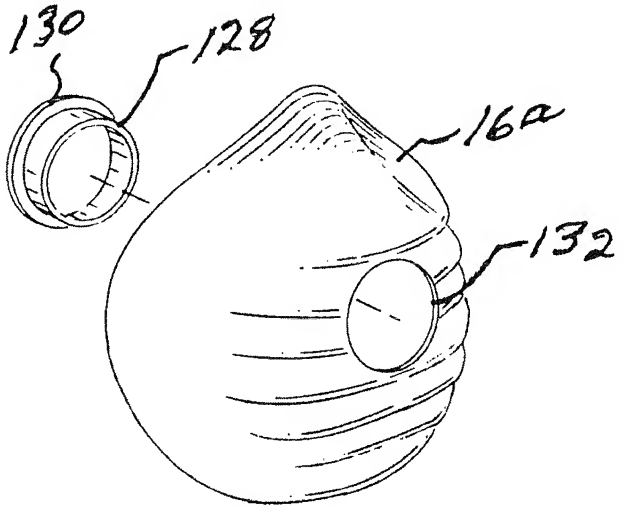


FIG. 8

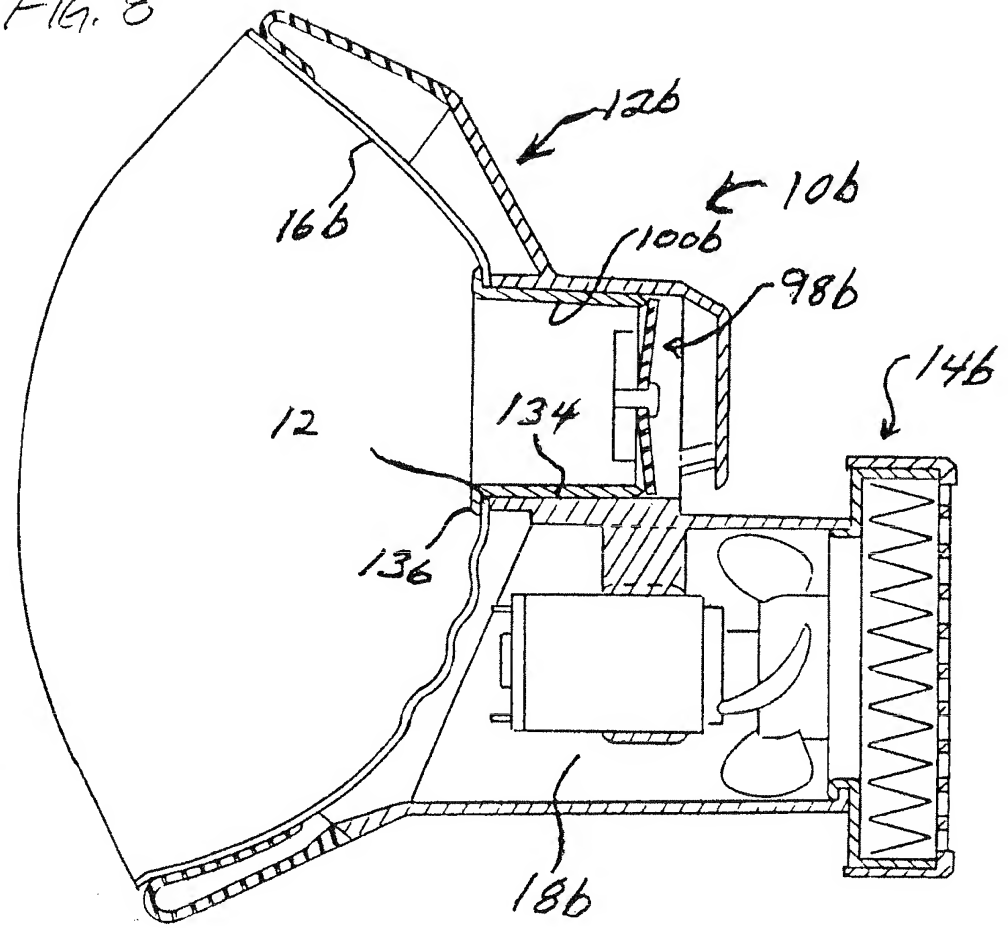
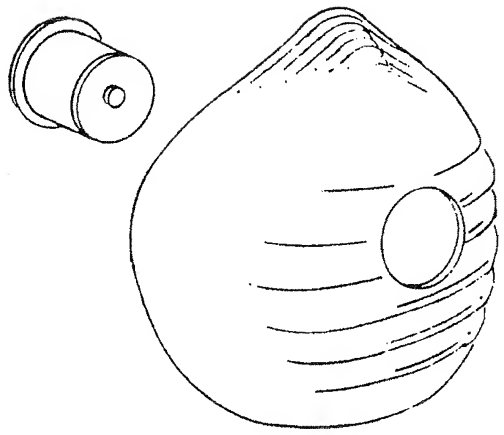


FIG. 9



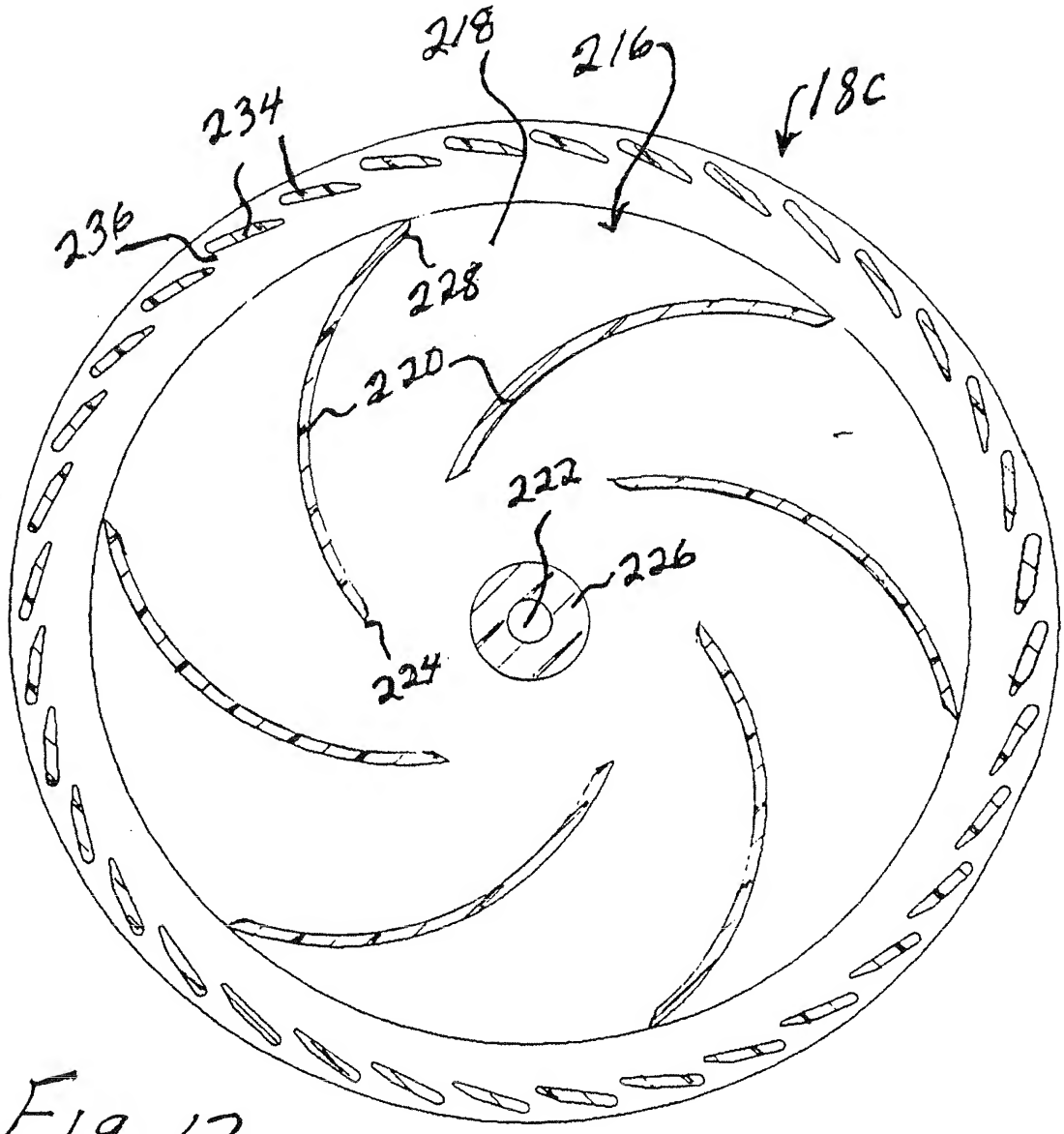


Fig 12

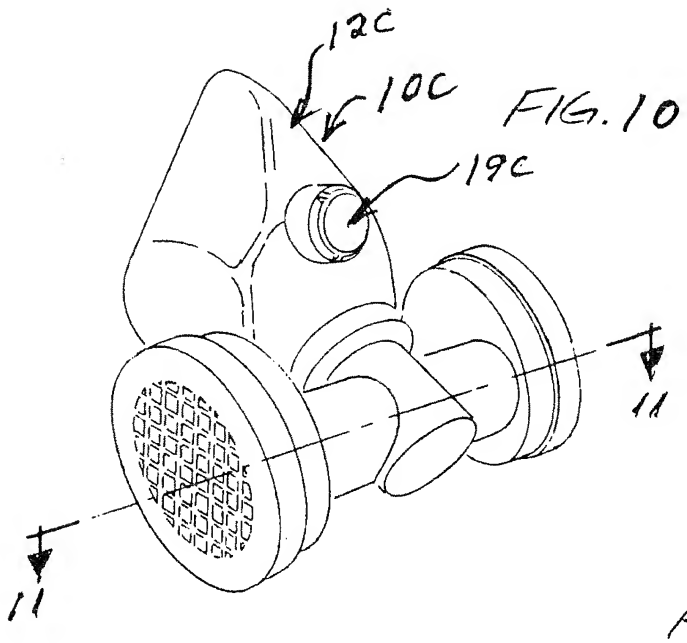
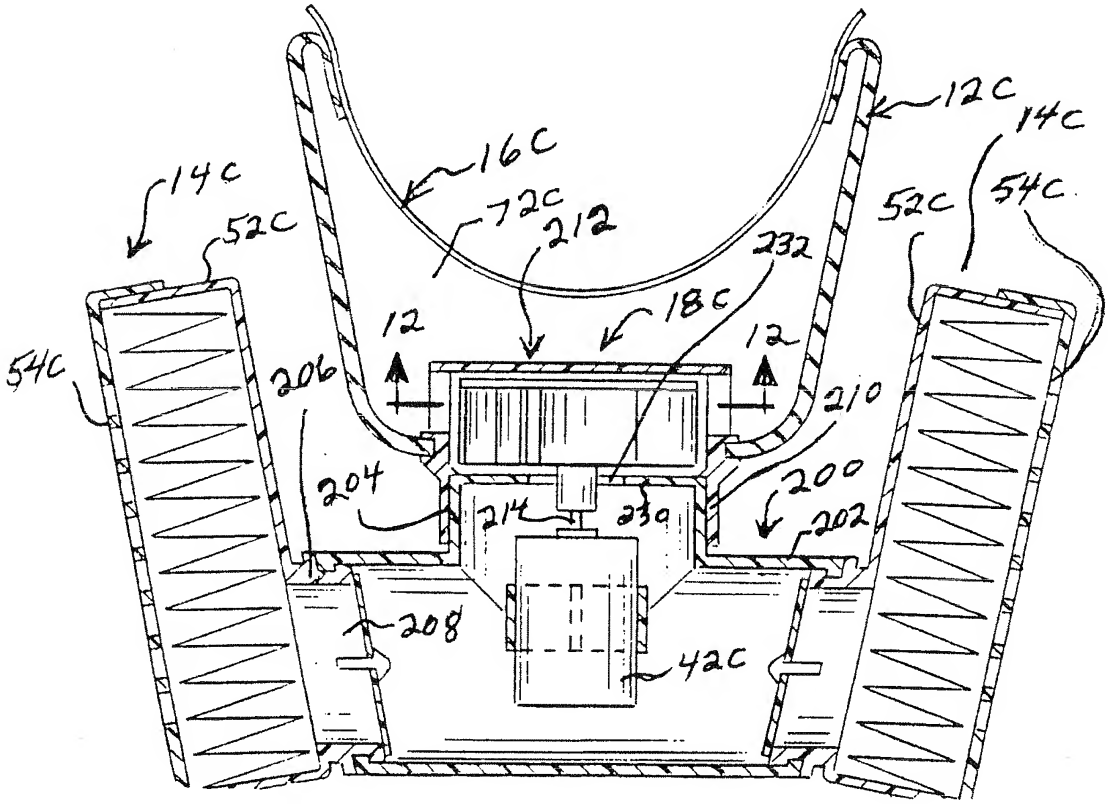

12C
10C
19C
11
11

FIG. 10

FIG. 11


12C
14C
16C
72C
212
232
18C
14C
52C
52C
54C
54C
12
12
206
210
204
214
230
200
202
208
42C

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 93 20 0525

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
Y A	DE-A-2 643 853 (DRÄGERWERK AG) * the whole document * ---	1,15 2-5	A62B18/00 A62B18/08
Y,D A	US-A-4 646 732 (CHAO-HUEI CHIEN) * the whole document * ---	1,15 7,9-11	
A,D	EP-A-0 130 707 (RACAL SAFETY LIMITED) * page 10, line 28 - page 13, line 25; claims 1,6-13; figures 6-10 * ---	1,2,7-9, 12	
A,D	GB-A-2 209 474 (CHAPMAN & SMITH LTD) * page 2, line 27 - page 4, line 28; figures 1-4 * ---	1,8,10, 11	
A,D	GB-A-2 118 625 (H G D ENTERPRISES LTD) * the whole document * -----	11-14	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

A62B
A41D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	10 JUNE 1993	GARNIER F.M.A.C.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P0401)